Finding Worlds That Look Like Stars
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Objective
Demonstrate methods developed by astronomers to discover asteroids, comets, and variable and exploding stars.

Keywords: comet, asteroid, discovery, positive/negative pair

Materials
Overhead projector
Transparencies and paper copies of sample sky charts

Discussion
Discovering new objects or changes in the sky is a daunting process. Thousands of stars are visible to the unaided eye, and the numbers increase geometrically as counts continue to fainter and fainter, telescopic limits. Astronomers searching the sky for discoveries take advantage of characteristics of the eye-brain combination to make changes and new objects in the sky apparent. Evolution has given humans great sensitivity to movement and stereo vision. Technology has made data recording and transformation possible. Utilizing these permits astronomers to discover new asteroids, comets, variable stars, and exploding stars. The star charts included with this activity show Saturn in three positions as it approaches and moves by the star Regulus in the constellation Leo, the lion. The ancients were aware of Mercury, Venus, Mars, Jupiter, and Saturn by observing just such motions, and their observations can be easily repeated during the right times of year. A well-built telescope and meticulous visual observing by William Herschel led to the discovery of Uranus. Mathematical studies of the motions of Uranus by John C. Adams and Urbain Leverrier, independently, led to the prediction and subsequent discovery of Neptune. Pluto was discovered after a careful photographic search of the sky.

The first asteroid was discovered by accident, but the next several hundred asteroids orbiting the Sun between Mars and Jupiter were discovered by careful visual searches. Now more than 10,000 are known, the bulk discovered photographically or with electronic imagers.

Procedure
The star charts included with this activity are exact copies of each other. The ones showing white stars on a dark sky should be referred to as positives. The ones showing black stars on a white sky should be called negatives. By combining a positive and a negative, a subtraction of the image is made. The so-called “difference image” will show any changes or differences between the pair of originals being compared.

Make one transparency of the positive and negative sheets and cut each transparency into thirds. This will be sufficient for a classroom demonstration with an overhead projector. If desired, a transparency and paper pair (one each positive and negative, either whole or in thirds) can be distributed to the students for their own experimentation individually or in groups.

For the classroom demonstration, use transparencies of both the positive and negative charts, cutting them into individual sections. Carefully overlay any one positive on any one negative. When the stars are accurately aligned, a uniform gray surface will be seen (though stars may not perfectly cancel out), with the exception of any waiting discoveries. The object to be discovered will be seen in two places. It will appear as a black spot in an area of gray sky or as a white spot where gray would be expected. The movement of the planet over the course of a few days causes the differences in positions.

Be prepared for poor alignment of the fixed stars. This can be caused by distortion introduced by the photocopier in making the transparencies and the paper copies. Make an initial pair of photocopies in advance to confirm that distortion isn't a problem. If distortion is a problem, try copying each individual section separately, centered on the copier's copy surface. The distortion is likely more pronounced near the edges of the copies.

After illustrating the technique using the projector, distribute random positive/negative paper/transparency pairs for the students to make their own discoveries. Each student should have at least one transparent copy and one paper copy, one being positive and the other negative.

<u>Extension</u>
Image differencing is commonly found in image processing software. Scanned images of terrestrial or celestial scenes can be differenced and studied for changes.

Two of the most successful comet and asteroid hunters, Eleanor Helin and Carolyn Shoemaker, use a different technique for making their discoveries. Two photographic images taken in the same direction but at different times are aligned under a stereomicroscope. The stereomicroscope feeds one image to one eye and the other image to the other eye. The brain then melds the two images. Any changes will not meld properly and will be seen as an object above or below the plane of the rest of the image.
This can be attempted in the classroom with inexpensive (or expensive!) stereoviewers, if available, or without magnification. Place two different paper images, aligned and immediately next to each other, on a tabletop. Place a card, roughly 12 cm high, between the pictures. Lean down and place the middle of your nose on the card, forcing one eye to see one picture and the other eye to see only the other picture. Do additional alignment of the pictures if necessary and then merge the images (this takes practice!) and look for spots "floating"above or below the main image. The floating spots are differences between the two pictures. Note that lighting has to be similar on both sides of the nose-card for this to work well.

<u>Standards</u>
A visit to the URL http://www.mcrel.org yielded the following standards and included benchmarks that may be applicable to this activity.

Level III Middle School (6-8) Science Standard 3. *Understands essential ideas about the composition and structure of the universe and the Earth's place in it.*
Knows characteristics and movement patterns of asteroids, comets, and meteors.

Level I Lower Elementary (K-2) Science Standard 12. Understands motion and the principles that explain it.
Knows that the position of an object can be described by locating it relative to another object or the background.

Level II Upper Elementary (3-5) Science Standard 12. Understands motion and the principles that explain it.
Knows that an object's motion can be described by tracing and measuring its position over time.

Level I Lower Elementary (K-2) Science Standard 15. *Understands the nature of scientific inquiry*.
Knows that learning can come from careful observations and simple experiments.

Level III Middle School (6-8) Science Standard 2. *Understands basic Earth processes.*
Knows that fossils provide important evidence of how life and environmental conditions have changed on the Earth over time (e.g., changes in atmospheric composition, movement of lithospheric plates, impact of an asteroid or comet).

NOTE: This activity is currently posted to the Cassini web site as a field-test version. Educators who use this activity for classroom demonstration purposes are encouraged to submit comments to the Cassini Education Outreach Coordinator. We are dedicated to providing high-quality activities for classroom use and welcome your suggestions.